DENTAL AGE ESTIMATION USING THE RADIOGRAPHIC VISIBILITY OF PERIODONTAL LIGAMENT AROUND LOWER THIRD MOLARS AMONG SELECTED NIGERIANS

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ABSTRACT

Background: **Age estimation for sporting activities, legal age determination and migration purpose is oftentimes essential, which makes the need for a scientifically proven method of age estimation an important aspect of medical practice. Forensic odontology is an essential aspect of forensic practice and may be a veritable tool in age estimation.**

Aim and Objective: **The objective of this study was to evaluate the usefulness of orthopantomograms (OPG) in age estimation among selected Nigerians.**

Methodology: **A retrospective assessment of 202 OPGs was done to review the visibility of the periodontal ligament of third molars with completed root formation according to the methods described by Olze et al (2010). Individual ages were then calculated by deducting date of exposure from the date of birth recorded in years. Mean age with standard deviation were calculated for each group.**

Results: **Assessing the minimum and maximum age at which each of the stages of the radiographic visibility of the periodontal ligament as seen on the OPGs revealed that there was a gradual increase in the age at which the stage increment occurred, with a few exceptions. Comparison of the radiographic visibility of the periodontal ligament revealed that males tend to achieve early periodontal visibility stages compared to females, but the reverse was observed in later stages. Age 17 is more than likely attained in any person found within stages 1 to 3 as the minimum age found in these stages were above 17 years.**

Conclusion: **With a few exceptions, the assessment of periodontal ligament visibility on OPGs can adequately predict the age of individuals. Thus, the use of this method may need to be combined with other methods in accurate determination of dental age in instances of forensic age estimation.**

Keyword: Age determination, Periodontal ligament, Orthopantomogram, Third molars, Forensic

INTRODUCTION

There are instances where establishment of the identity of an individual becomes very important. This may include the estimation of the age of affected individual, for instance in age-grade sporting activities, legal age, age estimation among migrants, and in cases of mass casualty or suspected murder cases.[1-3] Criminals in their bid to escape justice or illegal migrants seeking asylum may claim to be younger than 18 years of age, which may necessitate the determination of their true age, and this can be done with the use of forensic odontology.[1] There is bound to be changes to human body following death, either because of murder or mass casualty, but dental tissues will not decompose at the rate at which soft tissues does, and may be among the last set of tissues to decompose in dead human beings, which provides good source of materials for forensic investigation in case of suspicious death or insurance claim. There had also been instances where victims of serial killers were dissolved in acids, only for dental prosthesis to resist dissolution by the acid, which aids in the resolution of such cases.

The international interdisciplinary Study Group on Forensic Age Diagnostics put forward a guideline for forensic age estimation, which include the following:

a. Clinical examination, including anthropometric measures and assessment of sexual maturity signs
b. Radiographic examination of the left hand
c. Dental evaluation involving clinical examination and analysis of orthopantomograms (OPGs).

If the skeletal development of the hand is completed, an additional radiographic examination or CT-scan of the clavicles need to be done.[2] Different methods had been used in the assessment of the dental age

estimation and these include the assessment of the visibility of the periodontal ligament of completely erupted lower third molars on OPG.[4] The other method is the assessment of the root pulp visibility in the lower third molars, which is based on the idea that secondary dentine will keep being deposited in the pulp canal with the resultant narrowing of the pulp canal.[5] The upper third molars are usually not used because of the superimposition as a result of adjacent structures, which does not allow for clarity of the image in that area.[6] Olze *et al.* had reported the benefits of the use of radiographic visibility of periodontal membrane of fully mineralized third molars among Germans who are older than 21 years of age.[4] However, due to differences in dentition and eruption sequence from culture to culture, age estimation from one culture may not exactly fit into that of another culture. Therefore, there is the need for the assessment of the orthopantomograms (OPGs) among Nigerians, with the view of correlating with their ages to establish a baseline data for Nigerians. Previous studies reported among Nigerians gave a conflicting report of other methods used not being able to effectively predict the age of their studied population.[7,8] Therefore, this retrospective study of orthopantomograms was to assess the possibility of the use of the method described by Olze *et al.*[4] at assessing the radiographic visibility of periodontal membrane and correctly estimating ages of Nigerians.

METHODOLOGY

A cross sectional study involving the retrospective assessment of the orthopantomograms (OPGs) in the Department of Oral Pathology, University College Hospital, Ibadan, Nigeria was carried out. All the OPGs taken for adult patients attending our dental centre were assessed for clarity and other inclusion criteria between year 2019 and 2022.

Orthopantomograms that were clear enough for adequate diagnosis to be made, showing mandibular third molars with completed root formation and closed apex were included in the study.

Those with pathologic conditions such as jaw fracture, osteolytic lesions and carious lesions on the lower third molars were excluded.

Two hundred and two images, acquired with Planmeca digital OPG machine with Romexis software viewer version 19.2, met the inclusion criteria and those not meeting the criteria were excluded from the study. The OPGs that were included in the study were for routine investigations, excluding all those with pathologic affectation of the mandibular third molar regions. All the study populations included Nigerians and majority from the Yoruba tribe followed by the Igbo tribe. Descriptive analysis of the data was done to calculate the minimum and maximum age of respondents and the mean and median age with interquarter

Records of OPGs at the Department of Oral Pathology of the University College Hospital, Ibadan, Nigeria was assessed and the visibility of the periodontal ligament of third molars with completed root formation was assessed by two separate examiners using the criteria described by Olze *et al.*[4] (Fig. 1) as follows:

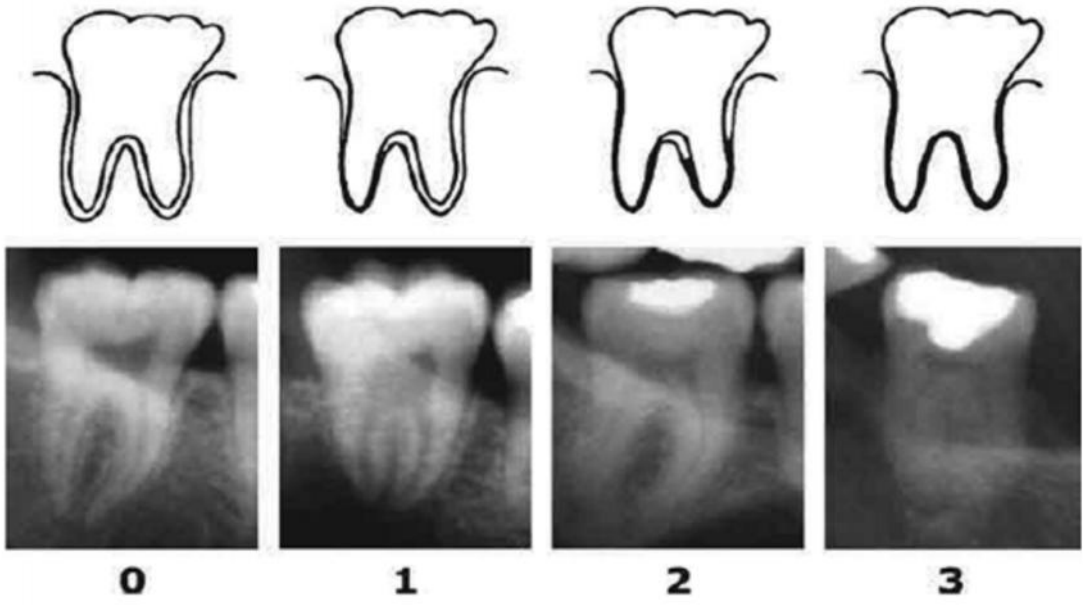

Fig. 1: Schematic diagrams and radiographs of the stages of periodontal ligament visibility in lower third molars (Adapted from Olze *et al.*, 2010[4]).

Stage 0 – The periodontal ligament is visible along the full length of all roots.
Stage 1 – The periodontal ligament is invisible in one root from apex to more than half root.
Stage 2 – The periodontal ligament is invisible along almost the full length of one root or along part of the root in two roots or both.
Stage 3 – The periodontal ligament is invisible along almost the full length of two roots.

Modification was made for third molars with single root as follows:
Stage 0 – The periodontal ligament is visible along the full length of the root.
Stage 1 – The periodontal ligament is invisible from apex to more than half root.
Stage 2 – The periodontal ligament is invisible along almost the full length of the root.

Case note number, sex, date of birth, date of radiographic exposure and the stage of radiographic visibility of the roots were recorded for each of the OPGs. Dates of birth and exposure were not known to the examiner in order to avoid bias. Individual ages were then calculated by deducting the date of exposure from the date of birth, which was recorded in years. A minimum and maximum age, median age with lower and upper quartiles and mean age with standard deviation was calculated for each group. The calculated age was then compared with the known chronologic age of the owners of the assessed OPG.

Data collected was collated, computed and subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS) Version 22. Descriptive statistics and significant relationships were presented using appropriate methods for qualitative and quantitative analysis. Qualitative variables were summarized by frequencies, percentages and proportions, and quantitative variables were summarized by means, standard deviations and confidence intervals. The intra and interobserver reliability for the grades of periodontal ligament visibility was assessed using Cohen's Kappa. Results were presented using tables and the level of statistical significance was set at a p-value of 0.05.

RESULTS

A total of 202 OPGs belonging to 90 (44.6%) males and 112 (55.4%) females were analysed with their ages ranging from 16- 40 years. Majority of the OPGs were for patients within the age range of 20 and 30 years (Table 1). Intra and interobserver reliability agreement was ≥ 0.97.

Table 1: Age and sex distribution of subjects

Age	Male (%)	Female (%)	Total (%)
16	4 (4.44)	2 (1.79)	6 (2.97)
17	5 (5.56)	4 (3.57)	9 (4.45)
18	5 (5.56)	14 (12.50)	19 (9.41)
19	5 (5.56)	4 (3.57)	9 (4.45)
20	3 (3.33)	6 (5.36)	9 (4.45)
21	2 (2.22)	2 (1.79)	4 (1.98)
22	5 (5.56)	11 (9.82)	16 (7.92)
23	4 (4.44)	6 (5.36)	10 (4.95)
24	10 (11.11)	13 (11.61)	23 (11.39)
25	3 (3.33)	5 (4.46)	8 (3.96)
26	1 (1.11)	5 (4.46)	6 (2.97)
27	3 (3.33)	7 (6.25)	10 (4.95)
28	3 (3.33)	8 (7.14)	11 (5.45)
29	2 (2.22)	4 (3.57)	6 (2.97)
30	0 (0)	2 (1.79)	2 (0.99)
31	3 (3.33)	1 (0.89)	4 (1.98)
32	3 (3.33)	2 (1.79)	5 (2.48)
33	1 (1.11)	5 (4.46)	6 (2.97)
34	5 (5.56)	2 (1.79)	7 (3.47)
35	3 (3.33)	0 (0)	3 (1.49)
36	6 (6.67)	2 (1.79)	8 (3.96)
37	5 (5.56)	4 (3.57)	9 (4.45)
38	3 (3.33)	2 (1.79)	5 (2.48)
39	4 (4.44)	1 (0.89)	5 (2.48)
40	2 (2.22)	0 (0)	2 (0.99)
Total	90 (100.0)	112 (100.0)	202 (100.0)

Table 2: Age in years of the stages of radiographic visibility of the periodontal ligament of teeth 38 and 48 in subjects.

Tooth	Stage	Number (%)	Min	Max	LQ	Median	UQ	Mean	SD
38	0	90 (44.55)	16.04	28.08	18.04	20.02	24.01	20.98	3.50
	1	62 (30.69)	17.02	34.08	23.09	25.07	30.02	26.29	4.53
	2	39 (19.31)	26.04	39.11	32.02	36.04	37.08	34.53	4.03
	3	11 (5.45)	26.02	40.06	29.05	36.07	38.02	34.40	4.76
48	0	97 (48.02)	16.04	34.05	18.05	20.05	24.02	21.05	3.60
	1	48 (23.76)	22.00	34.08	24.01	26.10	29.07	26.78	3.73
	2	46 (22.77)	18.02	39.11	32.04	36.03	37.07	33.79	5.19
	3	11 (5.45)	26.02	40.06	29.05	32.01	37.06	32.94	4.89

Min – minimum age, Max – maximum age, SD – standard deviation, LQ – lower quartile, UQ – upper quartile.

When the minimum and maximum age at which each of the stages of the radiographic visibility of the periodontal ligament as observed on the OPGs was assessed, it was revealed that there was a gradual increase in the age at which the stage increment occurred, with a few exceptions. For tooth 38, the minimum age at which stage 2 was seen was higher than that at which stage 3 was observed. The same discrepancy was noticed between stages 1 and 2 for tooth 48 (Table 2). When the stages of the radiographic visibility of the periodontal ligament was compared between males and females, it was discovered that stage 0 appeared earlier among males at the age of 16.04 compared with 16.07 for their female counterparts. The same trend was seen in stage 3, which was first observed between 29.01 in females and 26.02 in males. The earliest appearance of stage 2 in females was 18.02 years and 26.04 years in males. Stage 1 was first achieved by females between 17.02 and 22.0 years while the male achieved the stage at 17.10 and 22.07 years (Table 3 and 4).

The median age tends to increase with the increasing stages of the radiographic visibility of the periodontal ligament, with few exceptions among both males and females. The median age at which stages 0 and 1 were seen was lower among males compared with their female counterparts, but the reverse was the case for stages 2 and 3. For stage 0, the medians vary for the females between 21.0 and 22.0 years while it was 19.08

Table 3: Age in years of the stages of radiographic visibility of the periodontal ligament of teeth 38 and 48 in male subjects.

Tooth	Stage	Number (%)	Min	Max	LQ	Median	UQ	Mean	SD
38	0	33 (36.66)	16.04	28.06	17.09	19.08	23.03	20.18	3.32
	1	25 (27.78)	17.10	34.05	23.55	24.11	30.05	26.02	4.54
	2	25 (27.78)	26.04	39.11	33.52	36.06	37.58	35.17	3.48
	3	7 (7.78)	26.02	40.06	32.01	37.06	40.00	35.32	5.06
48	0	36 (40.0)	16.04	28.06	17.10	19.08	23.04	20.06	3.11
	1	22 (24.44)	22.07	34.05	24.02	26.06	31.03	27.01	3.99
	2	23 (25.56)	26.04	39.11	35.06	36.09	38.08	36.10	2.79
	3	9 (10.0)	26.02	40.06	28.55	32.01	38.53	32.92	5.09

Min – minimum age, Max – maximum age, SD – standard deviation, LQ – lower quartile, UQ – upper quartile.

Table 4: Age in years of the stages of radiographic visibility of the periodontal ligament of teeth 38 and 48 in female subjects

Tooth	Stage	Number (%)	Min	Max	LQ	Median	UQ	Mean	SD
38	0	57 (50.89)	16.07	28.08	18.06	21.00	24.09	21.45	3.55
	1	37 (33.04)	17.02	34.08	23.05	25.11	30.03	26.48	4.57
	2	14 (12.50)	26.11	39.07	27.03	34.56	37.29	33.40	4.80
	3	4 (3.57)	29.01	37.00	29.02	32.56	36.77	32.78	4.35
48	0	61 (54.46)	16.07	34.05	18.06	22.00	24.06	21.64	3.76
	1	26 (23.21)	22.00	34.08	23.77	26.10	28.32	26.59	3.57
	2	23 (20.54)	18.02	39.07	27.04	33.00	37.00	31.47	6.00
	3	2 (1.79)	29.05	37.04	29.05	33.05	33.05	33.05	5.65

Min – minimum age, Max – maximum age, SD – standard deviation, LQ – lower quartile, UQ – upper quartile.

years for the males. The median age for stage 1 among females varies between 25.11 and 26.10 years, while the range was 24.11 to 26.06 years for males. For stage 2, the median was between 33.00 and 36.09. For stage 3, the median varied between 32.01 and 37.06 years (Tables 3 and 4).

DISCUSSION

The data analysed in this study comprised that of individuals with age ranging from 16 to 40 years, which were not randomly selected due to limitation of prospective radiographic laws for such a study like this. Only retrospective radiographic materials archived for diagnostic purposes were available for use in this study. On OPG radiographs, only the mandibular third molars were evaluated as periodontal assessment of the upper molars may be obscured by superimposition of other facial bones or bony structures as opined by Olze *et al.* 2010.[4]

Many countries of the world attached great significance to maturity age and accepted the legal age of maturity as 18 years based on the 1989 United Nations Convention on the rights of the child.[9] Despite some minor differences between gender in the time sequence of teeth mineralisation, it has been reported that mineralisation of the third molars' root starts at the age of 15 years and the root fully formed at about 20 years.[10] The biological background of periodontal membrane disappearance has been ascribed to membrane narrowing to a point that one cannot see it on radiographs and tooth root roughness with time.[4] It was observed in this study that the radiographic image of the periodontal ligament disappears sometime after the age of 22 years. This agrees with the study by Olze *et al.* 2010[4] that observed similar periodontal ligament disappearance sometime after the age of 20 years. This study assessed the possibility of the stages to prove if it can be of use in cases of forensic age estimation for black African population. The results revealed that the minimum and the median ages of the subjects in both genders increased with increasing stages.

With this study, the minimum age for stages 1 to 3 was above 17 years of age, which implies that age 17 is more than likely attained in any person found within these stages. Our findings contrast with that of Olze *et al.*, 2010[4] that observed the minimum age for stages 1 to 3 to be over 18 years of age. The finding in this study could have been as a result of the earlier eruption sequence that had been reported among the Blacks in comparison with their Caucasian counterparts.[12,13,14,15] The authors presumed that this could be due to genetic variations and diet among the black African populations, further study will be needed to verify this possibility. In Nigeria and other African countries, it could be safer to exclude that person to be under 17 years of age. This is a year lower than the Caucasian value of 18 years as reported by olze *et al.*, 2010.[4]

Findings from this study suggests that males tend to achieve early periodontal visibility stages compared to females, but the reverse was observed in later stages, which correspond to maturation phase of tooth development. Similar findings have been reported in which males achieved early 3rd molar developmental stages compared to females with a reverse trend in late stages.[12,14,15,16] This trend could have been due to genetic or hormonal factors, which is beyond the scope of the present study. The possibility of the trend being due to genetic factor is further strengthen by the findings of Blankenship *et al.*, where similar trend was reported among people of different ethnic background.[12]

Our investigation revealed that from stage 2 all male individuals were above the age 26 years, the females showed slight variation with stage 2 having 18 years as minimum level. Thus, the authors are of the opinion that the findings could be more applicable for male subjects during the initial stages and females at later stages of development. The complexity in minimum age at late stages will require further investigation. Our findings suggest that the periodontal ligament visibility could be applicable in cases of forensic age estimation in black population within certain limit. The limitation of this study being a non-randomized retrospective study and institutional based study did not allow for variability of results in terms of gender and ethnicity. Our recommendation for future study will be a prospective multicenter study with a mixed study population of major ethnic group within the country.

CONCLUSION

With a few exceptions, the assessment of periodontal ligament visibility on OPGs can adequately predict the age of individuals. Thus, the use of this method may need to be combined with other methods in accurate determination of dental age in instances of forensic age estimation.

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